Sulfenamide Accelerator Testing Rationale

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2-(Morpholinothio)benzothiazole
CAS No.: 102-77-2

Rubber and Plastic Additives Panel
American Chemistry Council
August 2003

List of Member Companies in the Rubber and Plastic Additives Panel

The Rubber and Plastic Additives Panel of the American Chemistry Council include the following member companies: Alco Chemicals; Bayer Polymers LLC; Ciba Specialty Chemicals Corporation; Crompton Corporation; Eliokem, Inc.; Flexsys America L.P.; The Goodyear Tire & Rubber Company; The Lubrizol Corporation; Noveon, Inc.; and, R.T. Vanderbilt Company, Inc.

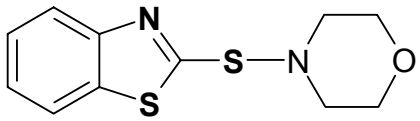
Executive Summary

The American Chemistry Council's Rubber and Plastic Additives Panel (RAPA), and its member companies, hereby submit their revised test plan for the Sulfenamide Accelerators category of chemicals under the Environmental Protection Agency's High Production Volume (HPV) Challenge Program. This document and the accompanying revised robust summary document on CAS # 102-77-2 are revisions of documents submitted by the RAPA Panel in support of the category on December 3, 2001 and reflect consideration of comments received from EPA (dated August 14, 2002) and from Environmental Defense (dated May 7, 2002).

EPA disagreed that N-oxydiethylenebenzothiazole-2-sulfenamide (MBS)/analogs and N-oxydiethylene thiocarbamoyl-N'-oxydiethylenesulfenamide (OTOS) constitute a category. While chemistry and hazard of these chemicals overlap, the RAPA Panel has considered the comments and makes this revision to more clearly explain and substantiate the data. Therefore, the RAPA Panel will submit the two sponsored chemicals, individually. There is no longer a need to include the additional members of the Sulfenamide category since MBS is data rich. This document summarizes the available data for the individual chemical N-oxydiethylenebenzothiazole-2-sulfenamide (MBS), CAS No. 102-77-2.

In consideration of animal welfare concerns to minimize the use of animals in the testing of chemicals, the Panel has conducted an extensive literature search for all available data, published and unpublished. It has also performed an analysis of the adequacy of the existing data. Summaries of all endpoint studies can be found in the accompanied robust summary document of 2-(Morpholinothio)benzothiazole (CAS # 102-77-2).

The use of MBS in rubber products requires negligible water solubility, high organic/oil solubility, relatively low melting point and low vapor pressure. Existing data for MBS indicate that the chemical is of moderate concern for aquatic toxicity, low concern for persistence/bioaccumulation and low concern for mammalian toxicity. It is of moderate concern for skin irritation and allergic skin reaction. We conclude that there are sufficient data on MBS for purposes of the HPV Program and no additional testing is recommended.



102-77-2
2-(Morpholinothio)benzothiazole
(N-oxydiethylenebenzothiazole-2-sulfenamide)
(MBS)

Figure 1. Chemical structure

Physicochemical Properties

MBS is a room-temperature solid with relatively low melting point, low vapor pressure, negligible water solubility, high flash point, Log P value of 3.5, and subject to rapid hydrolysis. (See Table 1.)

Fate and Transport Characteristic

MBS has been shown to rapidly hydrolyze to its starting materials, especially under acidic conditions. The presence or absence of light does not significantly alter the degradation rate, so additional photodegradation data collection efforts are not considered necessary. AOP and Fugacity Level III calculations have also been provided for MBS. In practice, MBS has been shown not to partition to water or air if released into the environment due to its low water solubility and low vapor pressure. Calculated Bioconcentration Factors and Log P values indicate that these materials are not Persistent Organic Pollutants (POPs). For purposes of the HPV Program additional testing is not necessary for MBS. (See Table 1.)

Aquatic Toxicology

Data on acute fish toxicity, acute invertebrate toxicity, and algal toxicity of MBS were reviewed and found to be moderately to highly toxic to aquatic organisms. Acute studies on *fish* demonstrate a 96-hour LC_{50} ranging from 0.39 mg/l to 11.5 mg/l. Acute studies on *Daphnia magna* demonstrate a 48-hour EC_{50} of 4 mg/l. Acute studies on algae demonstrate a 96-hour EC_{50} of 2.0 mg/l. Sufficient data is available to adequately evaluate the toxicity to aquatic organisms for purposes of the HPV Program and no additional aquatic toxicity testing is proposed. (See Table 2.)

Mammalian Toxicology – Acute

Data on acute mammalian toxicity were reviewed, and the findings indicate a low concern for acute toxicity for MBS. Data are available for oral, inhalation, and dermal routes of exposure. MBS has been well tested for acute mammalian effects. Therefore, for purposes of the HPV Program, no additional acute mammalian toxicity testing is proposed. (See Table 3.)

Mammalian Toxicology – Repeated Dose Toxicity

Data from repeated-dose toxicity studies were reviewed, and sufficient data are available to adequately characterize the repeated dose toxicity of MBS for purposes of the HPV Program. Subchronic data are available for oral, inhalation, and dermal routes of exposure, and no additional testing is proposed. (See Table 3.)

Mammalian Toxicology - Mutagenicity

Data from bacterial reverse mutation assays and *in vivo* chromosome aberration studies, as well as additional supporting *in vitro* and *in vivo* genetic toxicity studies were reviewed. MBS has been adequately tested for mutagenicity for purposes of the HPV Program and no additional mutagenicity testing is proposed. (See Table 3.)

Carcinogenicity studies have also been performed on MBS and have demonstrated no carcinogenic effects. (See Table 4.)

Mammalian Toxicology - Reproductive and Developmental Toxicity

Several studies are available for Reproductive and Developmental Toxicity of MBS and indicate a low concern for toxicity. Therefore, MBS has been adequately tested for Reproductive and Developmental Toxicity for purposes of the HPV Program and no additional testing is proposed. (See Table 3.)

Beyond SIDS Endpoints

Studies on MBS have shown slight skin irritation in rabbits and slight to moderate eye irritation in rabbits. Several patch testing studies on humans demonstrate a tendency for dermal sensitization to MBS. (See Table 4.)

Conclusion and Test Plan

Existing data for MBS indicate that the chemical is of moderate concern for aquatic toxicity, low concern for persistence/bioaccumulation, and low concern for mammalian toxicity. It is of moderate concern for skin irritation and allergic skin reaction. The RAPA Panel concludes that there is sufficient data on the MBS for purposes of the HPV Program and no additional testing is recommended. (See Summary Table 5.)

Background Information: Manufacturing and Commercial Applications

Manufacturing

The Sulfenamide Accelerator Class of rubber additives has been manufactured in the USA for over 60 years. While there have been some modest process improvements to yield and quality, the general batch manufacturing process involves the controlled oxidation of either the sodium salt of 2-Mercaptobenzothiazole (Sodium MBT) or 2-Mercaptobenzothiazole Disulfide and a primary amine (Morpholine for MBS). The reaction is carried out using water as a solvent.

Commercial Applications

The sole commercial use of the Sulfenamide Accelerator compounds is as general purpose cure rate accelerators for natural and synthetic rubber vulcanization. They are widely used in the manufacture of automotive components and industrial rubber products such as tires, hoses, conveyer belts, bushings, seals, gaskets and windshield wiper blades. Shoe soles, rubber bands and racquet balls also use this class of compounds, as these compounds are economical, easy to use, and allow for comfortable processing safety margins for cure rate control. Typical usage for Sulfenamide accelerators is from 0.5 to 4 parts accelerator per every 100 parts of rubber (phr).

Shipping/Distribution

MBS is shipped extensively throughout the world from manufacturing plants located in North America, South America, Europe, Asia and Africa.

Worker/Consumer Exposure

MBS is sold only to large industrial users as ingredients for their rubber compounding processes. To the Panel's knowledge there are no other uses for these compounds, nor any direct consumer applications, and therefore no direct sales to the general public.

The chemical has been "Regulated for Use" by the Food and Drug Administration for various food contact applications in the following sections of 21 CFR:

177.2600	Rubber Articles Intended for Repeated Use	MBS

The rubber and plastics additives industry has a long safety record and sophisticated industrial users handle these materials. Exposure of workers handling Sulfenamide accelerator materials is likely to be more in the area of material packaging than from chemical manufacturing. MBS is made as pellets, powders and flakes. Product forms that minimize dust generation and mechanized materials handling systems of the large industrial users combine to keep exposures to minimum levels. However, during material packout at the manufacturing site and, to a somewhat lesser degree during weigh-up activities at the customer site, there is a potential for skin and inhalation exposure (nuisance dust is the primary route of worker exposure).

Consumer exposure is considered minimal. Only very small amounts are used in rubber processing, and the materials themselves become bound in the rubber matrix during the vulcanization process. The most likely route of consumer exposure is skin contact from rubber or latex articles. Skin irritation, or possibly an allergic skin reaction may occur, but only in sensitive individuals subjected to prolonged and repeated exposure, especially under moist conditions.

Table 1. Matrix of Available and Adequate Data on the Sulfenamide Accelerator, MBS

Physico-chemical Properties and Environmental Fate

Endpoint	N-oxydiethylenebenzothiazole-2-sulfenamide CAS# 102-77-2
Molecular Weight	252.4
Melting Point	82-88˚C
Boiling Point	decomposition @ 216˚ C
Relative Density	1.4g/cm^3 @ 20˚C
Vapour Pressure	2.013 x10^{-6} hPa @ 25˚C
Partition Coefficient (logP_{ow})	3.49
Water Solubility	0.039 mg /l @ 25˚C
Photodegradation	$T_{1/2}$ = 1.07 hr (in air) $T_{1/2}$ = 1 hr (in water)
Hydrolysis	24% degradation after 25 hr @ pH7 and 20˚C
Biodegradation	0 % after 28 day
Fugacity Level III	
Air (%)	<0.01
Water (%)	20.3
Soil (%)	78.8
Sediment (%)	0.94

Table 2. Matrix of Available and Adequate Data on the Sulfenamide Accelerator MBS

Ecotoxicity

Endpoint	N-oxydiethylenebenzothiazole-2-sulfenamide CAS# 102-77-2
Acute Fish Toxicity **96 hr LC50**	*L. macrochirus* = 11.5 mg/l *O. mykiss* = 0.31 mg/l *P. promelas* = 3.5 mg/l
Acute Invertebrate Toxicity **48 hr EC50**	*Daphnia magna* = 4 mg/l
Algal Toxicity **96 hr EC50**	Algae (obtained from US EPA Environmental Research Laboratories in Corvallis, Oregon) = 2 mg/l

Table 3. Matrix of Available and Adequate Data on the Sulfenamide Accelerator MBS

Mammalian Toxicity

Endpoint	N-oxydiethylenebenzothiazole-2-sulfenamide CAS# 102-77-2
Acute Toxicity	
Oral LD50	12,560 mg/kg bw (rat)
Inhalation LC50	> 151 mg/l (1 hr) (rat) > 0.09 mg/l (4 hr) (rat)
Dermal LD50	>5010 mg/kg bw (rabbit)
Repeated Dose **NOAEL=**	200 mg/kg bw (28D - oral - rat) 5 mg/kg bw (2 yr - oral- rat) 9.8 mg/m³ (28D - inhalation - rat) 2000 mg/kg bw (21D - dermal – rabbit)
Mutagenicity – gene mutation	Ames = negative CHO gene mutation (HGPRT) = negative Mouse lymphoma assay = positive (with metabolic activation) Sister chromatid exchange = negative *E. coli* DNA Damage & Repair = negative
Mutagenicity – chromosome aberration	Dominant Lethal (rat) = negative
Reproductive Toxicity	No effects on reproduction at doses up to 500 mg/kg bw (rat)
Developmental Toxicity **NOAEL =**	1000 mg/kg bw (rat)

Legend for Table 3:
CHO: Chinese hamster ovary cells

Table 4. Matrix of Available and Adequate Data on the Sulfenamide Accelerator MBS

Beyond SIDS Endpoints

Endpoint	N-oxydiethylenebenzothiazole-2-sulfenamide CAS# 102-77-2
Skin Irritation	Slightly irritating (rabbit)
Eye Irritation	Slightly-moderately irritating (rabbit)
Dermal Sensitization	Positive (human)
Carcinogenicity	No carcinogenic effects (2yr – oral – rat) (79wk – oral – mice)

Table 5. Test Plan for the Sulfenamide Accelerator Category

Endpoint	N-oxydiethylenebenzothiazole-2-sulfenamide CAS# 102-77-2
Melting Point	A
Boiling Point	A
Relative Density	A
Vapour Pressure	A, C
Partition Coefficient ($logP_{ow}$)	A
Water Solubility	A
Photodegradation	A, C
Hydrolysis	A
Biodegradability	A
Fugacity Level III	A, C
Acute Fish Toxicity	A
Acute Invertebrate Toxicity	A
Algal Toxicity	A
Acute Toxicity	A
Repeated Dose	A
Mutagenicity – gene mutation	A
Mutagenicity – chromosome aberration	A
Reproductive Toxicity	A
Developmental Toxicity	A

Legend for Table 5:
A = Adequate data available
C = Endpoint requirement fulfilled based on calculated data